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DETAILED DESIGN DOCUMENT
of
HEAVY MEDIA CYCLONE
CONTROL SYSTEM
for
COAL RESEARCH LABORATORY
PILOT PLANT
DEVON, ALBERTA

Prepared by
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1.0 INTRODUCTION

1.1 Scope of Document

The intent of this document is to describe the process configuration, instrumentation, control strategy, and control system hardware and software of the heavy media cyclone density control system being supplied by DATAP SYSTEMS to the Coal Research Laboratory (CRL).

This functional and design specification is one of several phases in the system development. Other phases include program design, production and debugging, equipment purchase, installation, and commissioning.

Customer feedback will be via regular meetings and monthly progress reports and narratives.

Once this design document is approved by CRL, it will form the basis of the system. Mutually agreed revisions will be documented as ammendments to this paper.

1.2 Objectives

The primary objective of the heavy medium cyclone density control system is to maintain the density of the cyclone feed medium at an operator adjustable setpoint (or cutpoint). The cutpoint is the major factor determining the sharpness of separation within the cyclone.

1.3 Software Design Philosophy

A top down design approach has been adapted to ensure modular and structured software design. The total system is being developed with all functions clearly outlined and the database structure configured before any application software is produced. Wherever possible, this application software will be table driven to ensure modularity and flexibility. This will provide easy additions and modifications to the target system.

2.0 MECHANICAL CONFIGURATION

The process configuration, designed by Simon-Carves, allows accurate density measurement and control, Heavy Medium Feed tank level control, and dilute medium tank level control.

Simon-Carves design is described in detail in Appendix C.

Important control features of this design are:

a) Installation of a 4 way distributor box. The four outputs are:
   - a flow for density measurement
   - a flow for direct addition to heavy medium feed tank
   - a flow for addition with the raw coal into the Heavy Medium Feed tank central tube
   - a control flow to the density control cone

c) Air bubbles will be eliminated in the gravity drop density measurement pipe via a full distributor compartment providing full pipe flow.

d) A nuclear densitometer will be used and requires a constantly full pipe.

e) A new Heavy Medium Feed tank with a central tube to provide proper mixing of the deslimed coal and medium. The tube directs the lower gravity coal into the vortex of the tank outlet to pump suction.

f) Automatic, continuously modulating density control cone for primary density control. This device will divert the required percentage of medium to the magnetic separator (or dilute medium loop) for density control and by-pass the remainder to the Heavy Medium Feed tank.

g) Automatic, ON/OFF control valve for water addition to the Heavy Medium circuit.

h) Remote manual on/off control for a vibrating belt type Fe_3O_4 feeder. The feed rate is adjustable from Ø to 3Ø tons per hour.

j) A dilute medium tank and circuit (with magnetic separator) for material balance. Level control for the dilute medium tank via an automatic on/off modulating control cone.

3.0 PROCESS CONTROL

3.1 Control Philosophy

Primary density control will be provided by a continuously modulating cone that will divert the required percentage of medium to the magnetic separator circuit in order to increase or decrease the density. By doing this the system is effectively capable of removing water from the medium as the moisture content of the raw coal varies.

The controller algorithm will allow the density to be reduced by timed addition of water via an on/off valve even if Ø% medium is being diverted to the dilute circuit.

Magnetite is added when required during a run, the operator console will allow addition if required.

The density measurement will be made by a nuclear densitometer, and will be compared with the cut-point in the density control algorithm.

The level in the dilute medium tank will also be controlled by a pneumatic cone. If the tank level is too high, some dilute medium will be diverted to the slimes tank.

3.2 Cone Control Algorithm

Due to the fact that material balance can be achieved at a specific cone position, a pulse

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amplitude modulation technique has been implemented for cone positioning control. The advantage of using this type of control action is that the controller designed is of a cautious nature.

Definitions:

Error, ε	Density $_{sp}$ - Density measured
ΔU	Percentage change in cone control output w.r.t. the equilibrium cone position.
U_E	Equilibrium Cone Position
U_C	Current cone o/p position
t_p	density control time period
t_w	cone control o/p pulse width

Strategy:

If $|\varepsilon| \leq$ Cone Control deadband

$U_C = U_E$ for $t = t_p$

If Cone Control deadband $\leq |\varepsilon| \leq$ water control deadband

If ε is positive

$U_C = U_E + \Delta U$ for $t = t_w$

$U_C = U_E$ for $t = t_p - t_w$

end if

else if ε is negative

$U_C = U_E - \Delta U$ for $t = t_w$

$U_C = U_E$ for $t = t_p - t_w$

end if

If $|\varepsilon|$ lies in the water control region, water control take effect.

$\Delta U = k * |\varepsilon| *$ scaling factor

k = Pulse amplitude modulation gain

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3.3 D.D.C. Algorithm for Water Control

A velocity type algorithm with two-mode control (proportional, integral) will be used. The advantages of a velocity algorithm are:

a) changes in the setpoint will not give a kick to the system
b) reset windup will not occur

The equation is:

$$V_{out} = \sum \Delta V$$

$$\Delta V = K_1*(M_{n-1}-M_n) - K_2*\frac{\Delta t}{60}(S.P.-M_n)$$

K_1 = K*KG
K_2 = K*KG*KR
ΔV = change required in controller value (for the pneumatic cones it is change in cone position; for water valve it is change in % open time)
K = pre-scalar
KG = proportional gain (100/% Proportional band)
KR = integral gain
Mn = measured variable
S.P. = setpoint
Δt = D.D.C. time period (sec)

Since the setpoint occurs only in the integral term, the integral gain should never be set to Ø.

More difficult processes with slower response times are best controlled by a modified equivalent PI control law of the form:

$$\Delta V = K_1 (M_n^* - M_n) + K_2^* \frac{\Delta t}{6\emptyset} (S.P. - M_n)$$

where M_n^* = measurement sampled shortly before M_n.

In fast control loops, (on/off water addition), where the control law is calculated every sampling period, M_n^* is the same as M_{n-1}. However, in slow and more difficult control loops, M_n^* would be the latest sample value previous to the control sample M_n. Thus the control sampling period may be considerably longer than the input sampling period.

3.4 Filter

A digital filter will be provided for density measurement to reduce the effects of noise. It will average the input samples during one filter period. The equation is:

$$y = \frac{1}{N} \sum_{i=1}^{N} X_i$$

y = filter output
x = filter input (density measurement)
N = # of input samples in one filter period

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3.5 Lags and Dead Times

Special consideration must be given to system responses in this circuit because of the large time constants that exist.

System capacity, flow velocitys and piping configuration have been used to estimate the dead time and time constant to be approximately 1 minute and 2 minutes respectively for the pneumatic cone density control loop.

Approximate system response to a step disturbances is illustrated on the following page for the density control loop.

Technically, the proper control sampling time to use for a given control loop is a function of the process dynamics and the control law used. In the dead time plus lag process, the best performance is usually at a control sampling period approximately equal to the overall process time constant. However the overall time constant of the density control system is extremely long (2-3 mins.) for the penumatic cone density loop. A control period of that length would be extremely sluggish in responding to setpoint changes.

Thus a shorter period (30 sec.) will be attempted initially with lower gains in the controller. The on/off water valve on the other hand has a much quicker response time therefore will have its own independent faster time period (10 sec. initially).

The control sampling periods will be easily adjustable during commissioning to arrive at the best performance. To provide more intimate control in emergency or shutdown situations manual overide for all controllers will be available.

4.0 INSTRUMENTATION

Process Control instrumentation to be added to the present installations are as follows:

a) Heavy Medium (H.M.) Tank continuous level monitor with high/low level alarms via computer interface and control. A flange mounted differential pressure unit mounted on the side of the tank at the low level point will be used. It uses direct electronic sensing of pressure variations on an exposed isolating diaphragm to measure changes in tank level. Accuracy is ± 0.25% of calibrated span.

   The unit provides continuous accurate measurement of the tank level via a proportional 4-20 milliamp indicating converter interfaced with the computer system. A high level alarm alerts the operator to a possible tank overflow. A low level alarm protects the pump from operating dry and indicates an excessive medium loss.

b) Densitometer - A non-contact nuclear unit clamped to the gravity drop density measurement pipe and also supported from the distributor box stand will provide continuous density measurement to a precision of ± 1% of span (which can be as low as 0.200 specific gravity units (SGU) giving an accuracy of 0.002 SGU). A 4-20 mA output proportional to

span is interfaced with the master computer to maintain set point density. The unit measures the amount of gamma radiation received by a detector depending upon the radiation absorption of the materials between the source and the detector. The amount of absorbed radiation varies with the density of the medium.

The gravity drop density measurment pipe is assured of being full at all times by the 2" to 1" pipe reducer below the measurement location.

c) Flowmeter - Two different units will be tested after the pilot plant is operational. The wiring for both will be placed now for comparisons at that time.

d) Magnetite Bin Feeder/Vibrator - A vibrator mounted on the side of the 10ft^3 hopper and a second vibrator on the pan feeder below can be manually controlled for adjustable feed rates from 0 to 100% capacity of 10 to 30 lb./hr.. Dribble and fast feed rates are available. This unit can be remotely stopped or started through an operator request at the computer.

e) A modulating pneumatic cylinder will position the density control cone over the two compartment distributor divider in proportion to the 4-20mA control signal initiated by the D.D.C. algorithm. This provides the fine density

control with proportional distribution to the magnetic separator for excess water, non-magnetic contaminant or magnetite removal. A similar on/off type unit will be used for dilute medium tank level control.

f) An open/close solenoid valve activated via the master computer density control algorithm will add water to the H.M. circuit as required.

All instrumentation will be wired to the central control room and interfaced with the master computer. Analog outputs will be 4-20 mA. Electrical power used will be 115V, 1 phase, 60 cycle with special power supplies incorporated with instrumentation controls where required.

5.0 CONTROL SYSTEM HARDWARE

5.1 Micromaster

The centre of the control system will be a WESDAC M2 Micromaster based on the MOTOROLA M6809 microprocessor and consisting of two types of printed circuit boards.

The main board contains the CPU, memory (EPROM, RAM), clock and logic circuits, parallel input-output interface, 9 serial asynchronous communication ports, and an arithmetic processor.

The second board will be a WESDAC M1 operating strictly as a slave used for input and output. It will be equipped for 40 status/alarm inputs, 16 open collector control outputs, 16 analog inputs, 2 analog outputs, and 4 accumulator inputs.

Power supplies with the micromaster will allow operation from standard 110 VAC.

5.2 Operator Console

The operator console will be a C.R.T. with a standard green/black screen with 24 x 80 fonts. It will have limited graphics capability for picture drawing.

The micromaster will communicate with the CRT at 96ØØ baud over one of the serial ports. All displays and operator dialogue will be via the operator console.

5.3 Logger

The micromaster will output status/alarm messages and the operators log to a printer operating at 180 characters per second.

5.4 Inter-CPU Communications

The Micromaster is required to pass various parameters to an HP9845 desk top computer. This will be done via one of the serial asynchronous communications ports. RS232 to HPIB translation will be done by an HP98Ø36A serial interface. The HP9845 has an extra HPIB port. HP9845 application software will easily obtain the parameters.

6.0 CONTROL SYSTEM SOFTWARE

6.1 Operating System

Application software will execute under RT69, a highly responsive event driven multiprogramming operating system designed for real-time process control, communications and information management systems.

RT69 is the software framework that allows available resources (memory, CPU time, and peripheral devices) to be shared by several tasks. A task is a portion of machine code that performs a specific function; a task is defined by convention since it overlaps with the definitions of "program" and "subroutine". A priority scheme establishes the relative importance of various tasks in the system. This allows a less important task to be interrupted to permit execution of a time critical task. For RT69, a fixed priority scheme is used to reduce scheduling overhead.

6.2 Parallel Input-Output

All field devices are driven from the input and output sections on the slave WESDAC board. The software controls this I/O via a parallel input-output bus interface. The Peripheral BUS Handler subroutines perform all input and output operations on the peripheral data bus.

Control output function operates relays according to a mask table (1 = energized, Ø = de-energized) and a timer table in the database. Any task may operate a relay by modifying these tables.

Analog output function periodically outputs the current raw counts to each D/A converter. It can provide output ramping if required.

The analog input function multiplexes 16 analogs in through the A/D converter and stores the raw value for processing. The scan rate for each analog is adjustable.

The status input task reads the field state of each status/alarm point and stores it in the database.

6.3 Data Processing

6.3.1 Introduction

This segment of the definition document deals with essentially two kinds of data processing carried out within the system structure. The classification is based on the data-types being received or being generated within the system. These are:

a) Discrete data (represented by single or multiple bit elements)

b) Analog data

It must be indicated here that there are several other data structures necessary for the application such as command processing, display management etc. The above mentioned data types are primarily the kinds of entities received from the field and hence the classification.

6.3.2 Discrete Data Processing

A mutual understanding of the terms 'ALARM', 'STATUS' and 'EVENT' is necessary to explain discrete data processing.

6.3.2.1 'Alarm points'

From a system aspect a discrete point which is generically associated with an alarm state is considered to be an 'ALARM' point. This point could

assume one of its two states; - alarm or normal (the descriptions could be different if so chosen).

There are two categories of 'ALARM points':

(1) Field derived 'ALARMS'. (These could be either in or out of the alarm state.)

(2) Computer derived 'ALARMS'. (Generated internally the various application processes such as analog limit violations, and yet treated uniformly as an 'ALARM point'). An 'ALARM point' in the system will be a single bit and may have a '1' or a 'Ø' as the alarm state.

Any (or all) of the ALARMS in the above two categories may have the additional qualifier of being a 'Priority Alarm'.

6.3.2.2 'STATUS points'

The term 'STATUS point' applies to the set of discrete points representing states of devices as derived from the field. Any status can change its state either due to a command being issued or other reasons. An uncommanded status change will normally be considered to be a situation equivalent to that of an 'ALARM point' entering its alarm state. This implies that the annunciation procedures associated with an uncommanded status change is similar

to that of an alarm point entering its alarm state.

6.3.2.3 EVENTS

The term 'EVENT' shall apply to a change in state of either of the above two categories. Therefore a point going into 'ALARM' or back to its 'NON-ALARM' state; or a unit turning 'ON' either commanded or uncommanded, are regarded as 'EVENTS'.

6.3.3 Events Processing

6.3.3.1 Events Detection

Events detection covers discrete data processing. As indicated earlier, this class of data is supplied from two sources; field derived and computer derived (e.g. analog limit violations). The periodic evaluation of the current state of any given discrete point results in the detection of an event (change). This event (as applied to each individual point) is analyzed with the aid of a series of qualifiers and classified as one of the following types of transition:-

a) Uncommanded STATUS changes
(e.g. valve opening without a command having been issued)

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b) Commanded STATUS changes
(e.g. valve opening with a command having been issued)

c) An 'ALARM POINT' entering its alarm state
(e.g. FLOWRATE HIGH)

d) An 'ALARM POINT' returning to its normal state.
(e.g. C.M.T. LEVEL NORMAL)

All the characterizations of discrete points are made at the creation phase of the system and must be specified with points list and display requirements.

6.3.3.2 Events Logging

An occurrence of any of the above-mentioned transitions will result in text message being created in a format suitable for a log output which will indicate:

a) Date and time of detection of the event at the master.

b) An internal point number for the event.

c) The classification of the transition.

d) An event description.

e) A further qualification if required.

The detection of an event is recorded in a swift manner and is subsequently analysed and logged on the logger.

A typical event log format would be as follows:

82/07/16 22:10:04	Ø12	UNCMD	MAG. FEEDER	ON
DATE & TIME	Point Number	Class of event	Description of event	Qualifier

An event may be classified in one of the following ways:-

blank - Transition to a normal state or an expected change
UCST - Uncommanded Status change
ALRM - Alarm point transition to an alarm state
PTDB - Point disable
PTEB - Point enable
CMND - Command output
CMFL - Command fail
HLCH - High analog limit change
LLCH - Low analog limit change
PARM - Control Parameter change

Any time an event classified as an "ALARM" or "UCST" occurs, the audible C.R.T. bell will be sounded.

6.3.4 Analog Data Type Processing

The term 'analog' is a generic that signifies the variables in the system expressed as real numbers. The analog data originates in the field. The digital data representation of the magnitude and sign of an analog is the raw state of its integer form. Within the constraints of the digital representation, the precision of the analog variable is attempted to be maximized.

The A/D converters, which are 12 bits wide in precision, can accommodate a range limited to 0-8195. Any variable consequently, has to be expanded over this range.

The analog data in its raw form is 15 bits wide, comprised of 12 bits of integer representation, one bit for sign and two bits for under-range/over-range indicators. When either of these indicators are set, the only action performed is the annunication of the event. The last good reading is retained but flagged. However when good raw readings are obtained the data is converted to an integer or floating point value and a linear transformation of the type ($y = mx + c$) is performed to obtain engineering units. The calculated variable is then checked for high and low limit violations with a hysteresis (dead band) being applied to prevent a fluttering variable from causing a series of non-significant alarms. When an analog is dis-

abled, the conversion is entirely ignored for that particular variable.

Also classified as analog type data are software generated real numbers including analog limits, control parameters, and accumulated values. These values are either operator adjustable or generated from internal software.

6.4 Process Control

The process control function was described in detail in section 3. It will execute once a second. On each execution the algorithm timers will be decremented. When they reach zero the process control for that element will be performed, the required outputs activated, and the algorithm timer reset.

Automatic control can be initiated via the AC dialogue. Individual controls can be manually overridden by the CT dialogue, while control loop parameters (and limits and deadbands) can be altered with the FC dialogue.

6.5 Operator Interface

The devices and program modules which facilitate exchanges of information and requests between operator and the field comprise an important and major aspect of the computer automation system. It is broadly referred to as the "Operator Interface". The role of this interface is to present data and information to allow the operator to enter data and parameters that will control the field as desired. These interactions between the operator and the computer must be conducted in a comprehensive, concise, logical and error-forgiving manner so the operator may maintain a continuous, intimate awareness of the heavy media circuit operating conditions. This awareness, should be available with lttle regard for the intervening activities of the computer system.

The operator interface is composed of a monochromatic CRT and a logger. The CRT is used for both displays and operator input to the system.

6.5.1 C.R.T. Displays

The operator's console will be a standard green/black CRT with limited graphics capability primarily used for the circuit diagram. There are several displays available to the operator consisting of both alphanumeric pages containing status, alarm, analog information and a pictorial schematic of the circuit. The general format of all pages is

identical. The top line is reserved for the date, time and page title. The bottom line is reserved for operator dialogue. The second from the bottom line may be used to display the most recent event that has been logged. In between is the display area. While present on the screen, a display page will be periodically refreshed with updated data. A hard copy of all pages except the circuit diagram may be obtained on the printer. Each page is described in detail in the following sections. The illustrations shown are for example only and will probably not be the same as the final displays.

6.5.1.1 History Page

This page will show the last 20 events that have occurred listing their time of occurrence, point number, point description, and qualifier if required. The most recent events will be at the top, the older at the bottom. These events will be the same as the events log printout.

6.5.1.2 Circuit Diagram

This page is a symbolic representation of the H.M.C. circuit layout. It shows all of the major components in the controller circuit. It also shows some of the important analog, status and control variables sush as:

- magnetite feeder state (on/off)
- measured density
- cutpoint
- H.M. tank level
- dilute medium tank level
- flowrate
- control outputs

When this page is first requested the static portions and dynamic values are both drawn. Thereafter only the dynamic values are refreshed to provide faster response.

6.5.1.3 Status Page

This page shows the current state of all status points. The state word will be inverse if it is unacknowledged. An acknowledge from this page will restore the state to normal. The position of the messages is fixed (as determined by a driver table). Controllable status points are preceded by a two digit point number to be used with the control dialog CT.

For most points, a change of state is expected when a control is issued. When a command is initiated the status point expected to change state is shown in inverse video. A timer is initiated. The inverse video is cleared when the point changes state or the timer expires and a command fail is logged.

6.5.1.4 Alarm Page

This page shows alarm points in the alarm state and alarm points in the alarm or normal state which have not been acknowledge. The states of unacknowledged alarms will be inverse video. When unacknowledged alarms in the normal state are acknowledge, they disappear from the display.

The page will hold a maximum of 39 alarms. The 40th alarm will be "OVERFLOW".

All unacknowledged alarms always appear first on this page.

6.5.1.5 Analog Page

This page shows the implemented analogs. They may be of software or hardware origin. Hardware analogs will be followed by an asterik (*) if the current analog input is out of range of the A/D. If a hardware analog is currently in high or low alarm state, the letter "H" or "L" will follow the analog value.

Several software generated analogs are also displayed.

Some of the analogs shown will be used mainly for commissioning and may subsequently be removed.

6.5.1.6 Disabled Points Page

This page displays the point number and message of a disabled status/alarm point.

When a point is disabled, it's associated bit in DSTAB plane is set and it appears on this page. It will disappear from its associated status or alarm.

If more than 39 points are disabled, the last message will be "OVERFLOW".

6.5.1.7 Menu Page

This page displays all the options available to the operator via the CRT console keyboard.

The options are broken into 2 categories: one for diaplay selection, and one for all other actions.

These options are outlined in section 6.5.2

6.5.2 Dialogue

The operator dialogue is accomplished via the CRT keyboard and the bottom line of the CRT screen. All functions are initiated by typing a 2 letter code on the keyboard. This will cause a response (or prompt) or series of questions by the computer. All operator entries except for the 2 character function code should be terminated by a carriage return (↵).

There are two basic categories of functions, display selection and commands.

6.5.2.1 Display Selection Functions

As the name implies these functions are used by the operator to select or change display. This may be done by directly typing the displays code, or by using the next page/previous page functions.

The codes are:

AL - Alarm Page
AN - Analog Page
CI - Circuit Diagram Page
DI - Disabled Points Page
HE - Menu (or Help) Page
HI - History Page
ST - Status Page
NP - Next Page
PP - Previous Page

6.5.2.2 Commands

All operator functions which are not display selections are loosely termed "commands". The complexity of the action required is function dependent. The functions are listed below. Some of the functions require proper entry of a password before any action is taken. In the example scenarios shown the operator responses are underlined. Improper or error responses will cause warning messages and may abort the sequences.

AA - Acknowledge All

This function acknowledges all outstanding alarms and silences the CRT bell. The sequence is:

AA Acknowledge All. Password? XXX↓> Done.

AK - Acknowledge Alarm

This function acknowledges any unacked alarm or uncommanded status on the currently displayed page. It can only be executed from the Status or the Alarm pages. The sequence is:

AK Acknowledge > Done

CP - Control Parameter Change

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This dialogue is used to alter any of the D.D.C. control parameters (gains, time periods, controller outputs), or setpoints, or analog limits.

The computer will ask for the associated analog number which can be obtained from the analog page. It will then prompt the description and current value and ask for the new value. An example sequence is:

CP Control Parameter Change. Enter Associated Analog #. 22↓

22 Density KD Gain 3.Ø. Enter New Value? 4.1↓>
Done.

The newly entered value will immediately appear on the analog page and a message will be logged to record the change.

Whenever a control loop output is manually set by this dialog it will remain at that value (i.e. manual overide of computer) until changed again or until the manual overide is cancelled via the MO dialogue.

CT - Control Dialogue

This function is used to energize and de-energize relays to control field devices. The dialogue will ask for the control number which is obtained from the status page. When the operator properly com-

pletes the sequence a message will be logged and the controlled device will be turned inverse video on the status page if a status change is expected.

When the expected status change occurs it will return to normal and a message will be logged. If it does not occur within the timeout period a "command fail" message is logged. An example sequence is:

CT Control Request Command #? ØØ

MAGNETITE HOPPER (O,C,A)? C↓ OFF (Y,N)? Y↓> Done.

The (O,C,A)? prompt stands for (Open, Close, Abort). Open and On are synonyms. Close and Off are synonyms. The (Y,N)? prompts gives the operator another chance to back out of the sequence.

Whenever a device that is normally automatically controlled by the computer is manually controlled via this dialogue, it becomes manually overiden until cleared by the MO dialogue.

DE - Online Debug

Immediately after invoking the option the message "PASSWORD?" will appear. After a correct response followed by a ↓ is entered, the screen will go blank. Input will be echoed starting at the top left of the CRT. This option allows all memory in

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the micro to be examined. Random access memory (RAM) can be altered.

NOTE: The ability to modify RAM memory requires caution as it is possible to crash the system.

To examine memory, a one to four digit hex address should be typed followed by a slash. The computer will output its contents as a two-digit hex number. To change the contents, a 1 to 2 digit number is typed followed by a ↵ or line feed. Typing a ↵ closes the location while a line feed will display and open the next location.

To repeatedly examine the same location, the space bar need only be typed. Previous locations can be opened by striking the delete key, rather than a ↵ or line feed.

↵ denotes a carrage return.

Erroreous inputs or attempts to change EPROM memory will result in a "?" being displayed.

TYPING THE ESCAPE KEY TERMINATES THIS OPTION.

DH - Disable Alarm Bell

This option will inhibit the bell from sounding for any alarm or uncommanded status change. It will

also cause the event "C.R.T. Alarm Bell Disabled" to be logged.

DH - Disable horn > Done.

EH - Enable Alarm Bell

This function is the opposite of Disable Alarm Bell.

DP - Disable Point

After this option is invoked the message "PT.NO.?" will appear. A three digit point number representing the nuisance status or alarm message should be keyed in followed by ↵.

If the point number is valid, the message type "PTDB" will be logged. If an invalid number is entered, the message "TRY AGAIN" will appear. The disabled point will now disappear from the affected station's status, line diagram, or alarm page and appear on the Disabled Points page. Disabling a disabled point will result in the error message "REQUEST REDUNDANT!".

DP - Disable Point. PT.NO.? Ø22↵.> Done.

EP - Enable Point

This function is the opposite of Disable Point option.

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LG - Operator Log Request

This function is a manual request for the operators log to be printed. The sequence is:

LG - Print Operator's Log > Done.

PC - Print C.R.T. Page

The display portion of any C.R.T. page except the circuit diagram can be logged at any time. While the page is being logged, the function cannot be reinvoked. The screen data is frozen while the display is being logged. The circuit diagram contains graphic symbols that cannot be handled by the printer, therefore is excluded. The sequence is:

PC - Print C.R.T. Page > Done.

MO - Manual Overide Cancel

This dialogue provides the operator the ability to turn the automatic process control back on for all controllers. The controllers are put into manual whenever the controlled device is altered by the operator. This is done via the CP dialogue for analog controllers and via the CT dialogue for ON/OFF type devices. Whenever a controller is in manual mode an alarm point will appear on the alarm page for indication. This dialogue puts all controllers back on automatic. The sequence is:

MO - Manual OVERIDE CANCEL > Done.

TU - Time Update

After the option is invoked, the message "DATE/TIME (YY/MM/DD HH:MM:SS)?" will appear. The format must be followed exactly in relation to the slashes, spaces, and colons. The entire entry must contain two slashes in the date followed by a space and two colons in the time. Each entry can be a one or two digit number. If no numbers are entered, zero is assumed. Checks are made on the input for correct formats. The day of the month is checked in order to determine if it is valid for the month specified. Any error will result in the message "TRY AGAIN". If the "MASTER MICRO RESTART ALRM" message was outstanding at this time, the message "MASTER MICRO RESTART NRML" will be logged.

6.5.3 Logger

Three types of information may be printed. The primary use will be for events logging as described in 6.3.3.2.

Also available if required will be an operator's log to provide a concise hard copy of the current state of the system. While any log is being printed, status/alarm and event messages will be buffered since they are locked out. The log task will be table driven so that log formats can be easily defined or altered.

DATAPOINT SYSTEMS

Also printable is a hard copy of the C.R.T. page (except circuit diagram) as described in section 6.5.2.1. Once again events logging will be locked out while the page is being printed.

6.6 Inter - CPU Interface

Several pieces of data must be transmitted between the 68Ø9 micromaster and desk top computer.

HP9845 to 68Ø9: cutpoint

68Ø9 to HP9845: cyclone density, flowrate (future)

This will be accomplished via a serial port with the hardware described in section 5.4.

The 68Ø9 software will use HP protocol so that the currently existing and future HP programs can easily send and obtain the data. (via BASIC language statements such as READ, INPUT, PRINT, OUTPUT).

The use of HP protocol by the 68Ø9 will ensure CRL's programmers can make all necessary HP program changes with extreme ease.

DATAP SYSTEMS

6.7 Powerfail - Restart

The restart module will be initiated whenever the M2 card toggles the microprocessor restart line. This will occur on powerup, if software problems occur, or if the remote restart switch is closed. The restart packages initialize all required data and stack areas for proper operation. All RAM areas will be initialized with default operating values (for example cutpoint = 1.45). Thus previously entered parameters, or software analogs will be lost on a powerfail/restart and must be re-initialized.

6.8 Database

The database will be mainly organized around three types of data. The first is analog data, the second is discrete data represented by single or multi-bit elements, and the third is general data tables. Database access will be through a common set of subroutines.

6.8.1 Analog Data

Analog data will be kept in RAM tables that allow three bytes per analog. Each entry may be either a hardware or software value as described in other sections. The analog points list is found in the appendix.

Also associated with each analog is a definition table that contains such information as associated alarm bit numbers, type of analog, display format, description pointer, etc...

6.8.2 Discrete Data

Discrete data will be organized in bit planes (one bit per point). The planes are divided into 2 categories RAM and EPROM.

RAM tables are:

In-alarm Plane

Current Status Plane
Previous Status Plane
Commanded Points Plane
Disabled Points Plane
Unacknowedged Points Plane

EPROM tables are:

Implemented Points Plane
Multi-Status Points Plane
Alarm Points Plane
Normal State Plane
Never Alarm Plane
Priority Alarms Plane.

Also associated with each point in the system is a four byte descriptor that contains pointers to the state pair (i.e. ON/OFF) words and to the message descriptor.

6.8.3 General Data Tables

There are many general tables required for miscellaneous functions. Their format varies from type to type. The main ones are:

Message Dictionary
Word Dictionary
Log Driver Tables
Display Tables
Command Output Tables

DATAP SYSTEMS

7.0 INSTALLATION

Installation drawings and specifications will be provided by DATAP SYSTEMS.

CRL will:

a) install mechanical equipment.

b) place and terminate electrical cables to motors, etc..

c) place instrumentation cables from end devices to computer system (DATAP will terminate).

DATAP will:

a) coordinate material shipment.

b) provide installation supervision and recommendations as requried by CRL.

c) install microprocessor control equipment.

d) terminate instrumentation cables at field end and at computer.

8.0 OPERATION

8.1 Steps of Operation

The normal start of a "run" from the shutdown state will be as follows:

1. Start the system under manual control (as opposed to automatic) of feeder, control valve and actuator. Switch over to automatic control when density is close to cutpoint. Allow the system to settle at the cutpoint. Monitor all instruments.

2. Start adding coal and monitor all instruments while under automatic control.

8.2 Options of Operation

The normal mode of operation will be to run the circuit under automatic density control. Any or all of the devices can be put on manual override for special tests or upsets.

The procedure to dump slimes is as follows:

a) turn off coal for 1/2 hour.
b) manually divert a percentage of the medium to dilute circuit.
c) manually divert magnetic separator tailings to slimes tank.

DATAP SYSTEMS

9.0 COMMISSIONING

The most critical phase of this project will be during commissioning. All functions and equipment will be thoroughly tested for completeness, accuracy and reliability. Test procedures will individually test each device (both field and computer system) before trying any system tests. Once all components are functioning properly a series of overall control tests will be performed to select the controller periods and gains. These tests can be performed when the H.M.C. circuit is operating on medium only (i.e. no coal). The control loops will be tuned by the Systematic Trial Method. Finally system tests with coal will be used to verify all selected control parameters.

DATAP SYSTEMS

82/06/17 12:53:10 HISTORY PAGE

DATE	TIME	PT.#	TYPE	DESCRIPTION	STATE
82/06/17	12:53:08		CMND	MAG. FEEDER	OFF
82/06/17	12:49:15	021	UCST	MAG. FEEDER	ON
82/06/17	12:13:12			CUTPOINT SET	1.45
82/06/17	11:47:02	003		HP COMM	NRML
82/06/17	10:46:14	001		MICRO - RESTART	NRML
82/06/17	10:46:14	002		EVENT LOGGER	FAIL
82/06/17	10:46:14	003	ALRM	HP COMM	FAIL
82/06/17	10:46:14	001		MICRO - RESTART	ALRM
82/06/17	5:13:12	054	ALRM	CIRCUIT FLOWRATE	HIGH
82/06/17	5:12:49	052	UCST	C.M.T. SUMP PUMP	OFF
82/06/17	3:05:02			CUTPOINT SET	1.45
82/06/17	1:15:22		ALRM	DENSITY	LOW
82/06/17	24:12:12			C.M.T. LEVEL	NRML
82/06/16	23:59:15			DENSITY KG GAIN	3.3
82/06/16	23:14:14	012	ALRM	C.M.T. LEVEL	HIGH
82/06/16	22:22:22			DENSITY KG GAIN	3.Ø
82/06/16	21:21:21			CRT ALRM BELL	ENABLED
82/06/16	20:59:20			CRT ALRM BELL	DISABLED
82/06/16	20:59:20			LEVEL KR GAIN	6.Ø
82/06/16	19:15:20	123	ALRM	SPARE ANALOG	HI

NP: NEXT PAGE > DONE

82/06/17 12:53:10 STATUS PAGE

00	MAGNETITE FEEDER	OFF
Ø1	WATER ADDITION VALVE	CLOSED
	HEAVY MEDIA PUMP	ON
	DILUTE MEDIA PUMP	ON

PP: PREVIOUS PAGE > DONE

DATAP SYSTEMS

82/06/17 12:53:10 ALARM PAGE

CRT ALRM BELL	DISABLED	CMT LEVEL	HIGH
MEDIUM DENSITY	U/R	WATER VALVE MODE	MANUAL

TU: TIME UPDATE.ENTER DATE/TIME (YY/MM/DD HH:MM:SS)? 82/06/17 12:53:1

86/03/16 12:53:10 DEVON ANALOG PAGE

000	H. MED TANK LEVEL (M)	4.60	015	BESTOBELL FLOWRATE (M3/H)	0.00
05	DIL. MED TANK LEVEL	3.00	020	MINI MAG FLOWRATE (M3/H)	0.00
010	MEDIUM DENSITY (SGY)	1.250	042	CYCLONE CUTPOINT (SGU)	1.450
	DENS CTRL CONDE POS (%)	10		WATER ADD CYCLE (%ON)	00
067	CONE CONTROL DEADBAND	0.003	068	WATER CONTROL DEADBAND	0.010
043	CONE HEIGHT K FACTOR	1.00	046	WATER ADDITION KG	-1.00
044	CONE PULSE WIDTH (SEC)	60	047	WATER ADDITION KR	1.00
069	TREND METER (INTEGER)	50			
070	CONE POS. COR. FAC. (%)	00			
045	DENSITY TIME PERIOD (SEC)	90	048	WATER ADD PERIOD (SEC)	10
	DENSITY CONE DELTA V	00		WATER ADD DELTA V	00
049	DIL TANK LOW CTRL LVL	0.60			
050	DIL TANK HIGH COTRL LVL	0.65			

DATAP SYSTEMS

82/06/17 12:53:10 DISABLED POINTS PAGE

Ø5Ø C.M.T. LEVEL Ø84 CYCLONE FEED FLOWRATE

DP: DISABLE POINT. POINT NUMBER? Ø23 > DONE

DATAP SYSTEMS

82/06/17 12:53:54 MENU PAGE

DISPLAY SELECTION

AL - Alarm Page
AN - Analog Page
CI - Circuit Diagram
DI - Disabled Points
HE - Menu Page
HI - History Page
ST - Status Page

NP - Next Page
PP - Previous Page

COMMANDS

AA - Acknowledge All
AC - Start AUTO Control
AK - Acknowledge alarm
CT - Control Dialog
DE - Online Debug
DH - Disable Alarm Bell
DP - Disable Point

EH - Enable Alarm Bell
EP - Enable Point
LG - Operator Log request
PC - Print CRT Page
SI - Select Log Interval
TU - Time Update

HE > Menu Page. > DONE.

TABLE OF CONTENTS

SECTION 1 DATABASE

ANDTØ
ANLDR
ANLFMT
ANLIMT
ANLTYP
ANLØØ
CMDTB
DBCORE
DBDR
DBØØ
DSTBL
MESDC
MESSAGES
OPMSG
OPTDR
PNDØ1
RSTDIR
SAWDS
SNMGS
STDTB
WDDIC
XLOGTB

SECTION 2 DIALOG

OPCON
OPDBG
OP1
OP2
OP3
OP4
OP5
OPSUB
OPSUB2

SECTION 3 DISPLAY

ALARM
ANALOG
DISAB
DSPCOM
DSPLY
DSPSR
HELP
LINESR
PRINT
STATUS
SYSHS
SYSUP

SECTION 4 LOGGING

LFFS1
LFFS2
LFFS3
LFFS4

C1336/2

LFFS5
LFFS7
LFFS8
LFFTB
LOGF
SPF1
SPF2

SECTION 5 RTU FUNCTIONS

ANLDTA
ANLEQU
ANLG1
ANLPRO
AN3DRV
APPROX
BITSBR
CKSUM
DIV63
D2ADTA
D2AEQU
MUL33
QEDMSG
RFDTA
RLYDTA
RLYEQU
RLYSBR
RLYTSK
SCAN
SCNDTA
SCNEQU
TITEQU

TITINI
VIAINI

SECTION 6 SUBROUTINES

ANSUB
ASCIN
BIIB2
BUSIO
CLRSAN
CVTAS
DIVIDE
FORM
FPTD
FRZSAN
GPTM3
GTSTB
INASC
LDSUB
MLTPLY
MOVAN
MSSUB
NEWPG
SETLC
SNDCMD
STDANL
TANSUB
TRANS
UAHB
UBAH
WORD
ZERAN

DATA SYSTEMS

SECTION 7 OPTIONS

AIMAS
AUTOCL
CIDIAG
CIDTB
DENCTB
DENCTL
DRVTCL
EXCMND
FULSCL
HPINTF
LINSTR
LOGCTL
LOG1
OPRREP
ORTB
SCHED
SDLLBT
SELINT
SPECOP
SPFRSU
VIAINT

DATAPOINT

APPENDIX A Points List

#	Analogs
ØØ	Heavy Med Tank Level (FT)
Ø1	Dilute Med Tank Level (FT)
Ø2	Medium Density (SGU)
Ø3	Bestabell Flowrate (GPM)
Ø4	Mini Mag Flowrate (GPM)
Ø5	Spare H/W Analog
Ø6	"
Ø7	"
Ø8	"
Ø9	"
10	"
11	"
12	"
13	"
14	"
15	"
16	Density Control Cone Position (%)
17	Water Addition Duty Cycle (% ON)
18	Spare
19	Cyclone Cutpoint (SGU)
20	Spare
21	Density Cone KG
22	Density Cone KR
23	Density Cone Delta V
24	Density Time Period (sec)

DATAP SYSTEMS

#	Analogs
25	Spare
26	Water Addition KG
27	Water Addition KR
28	Water Addition Time Period (sec)
29	Spare
30	Dil Tank Low Cntrl Lvl
31	Dil Tank High Cntrl Lvl
33-39	Spare
40-79	Analog Low/High Limits
80-109	Analog Deadbands

Points Lists

#	STATUS I/P	1/Ø	STATUS
0	Master Micro Restart	ALRM/NRML	A
1	CRT Alarm Bell	ENAB/DSAB	S
2	Arithmetic Processor	ALRM/NRML	A
3	Spare		
4	Water Addition Mode	MAN/AUTO	S
5	Density Control Cone Mode	MAN/AUTO	S
6	Dil Lvl Cntrl Cone Mode	MAN/AUTO	S
7	Spare		
8	Magnetite Feeder	ON/OFF	
9	Cyclone Feed Pump	ON/OFF	S
10	Dilute Medium Pump	ON/OFF	S
11-39	Spare		
40	Water Addition Solenoid Valve	OPEN/CLSD	S
42	Dilute Lvl Cntrl Cone	TANK/DVRT	S
43-49	Spare		
5Ø-81	Analog Limit Alarms	LOW/ERR/HIGH/NRML	A
82-113	Analog I/P Alarms	UNDR/ERR/OVR/NRML	A
114-15Ø	Spare		

S = STATUS point
A = ALARM point

DATAP SYSTEMS

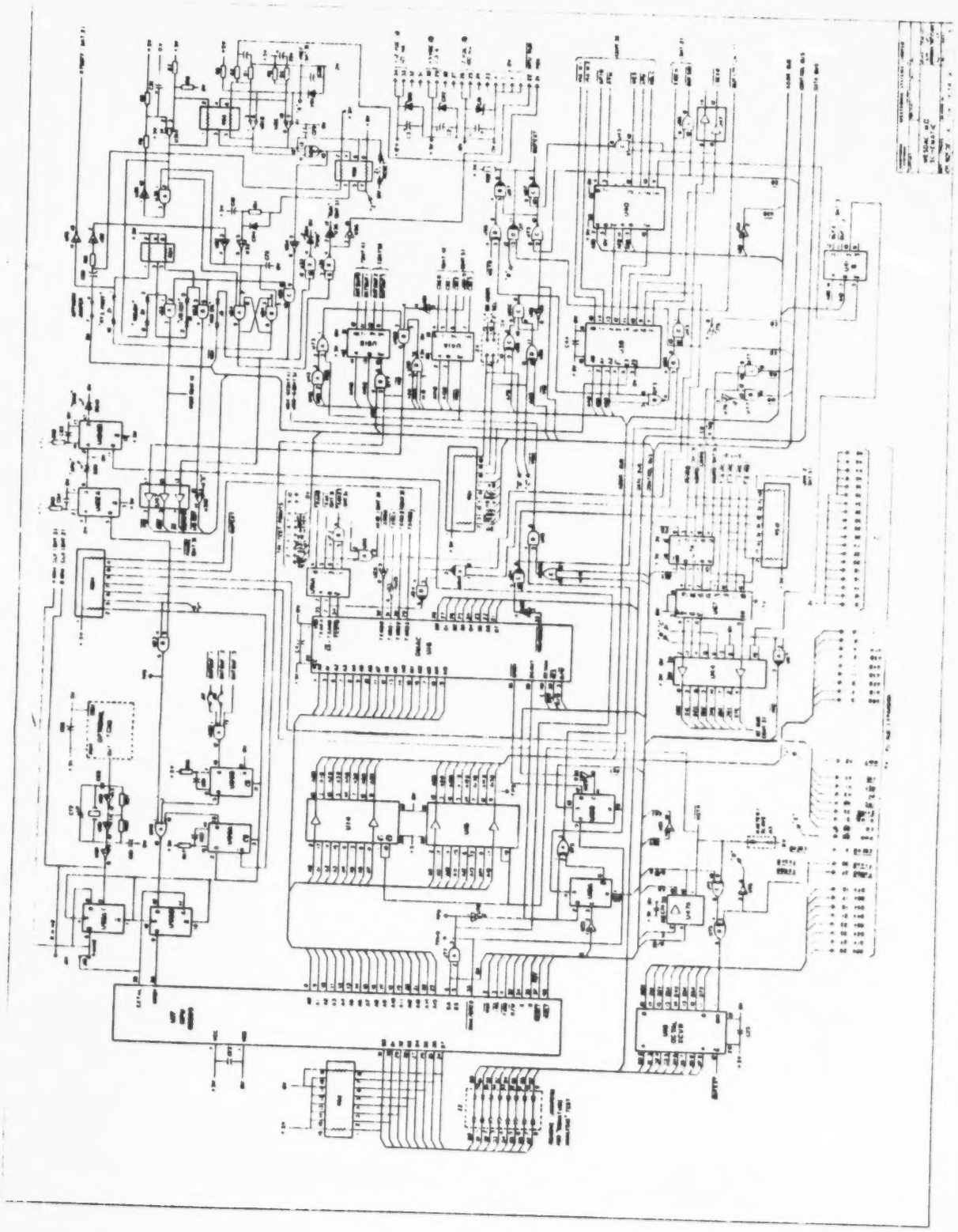
Output Points

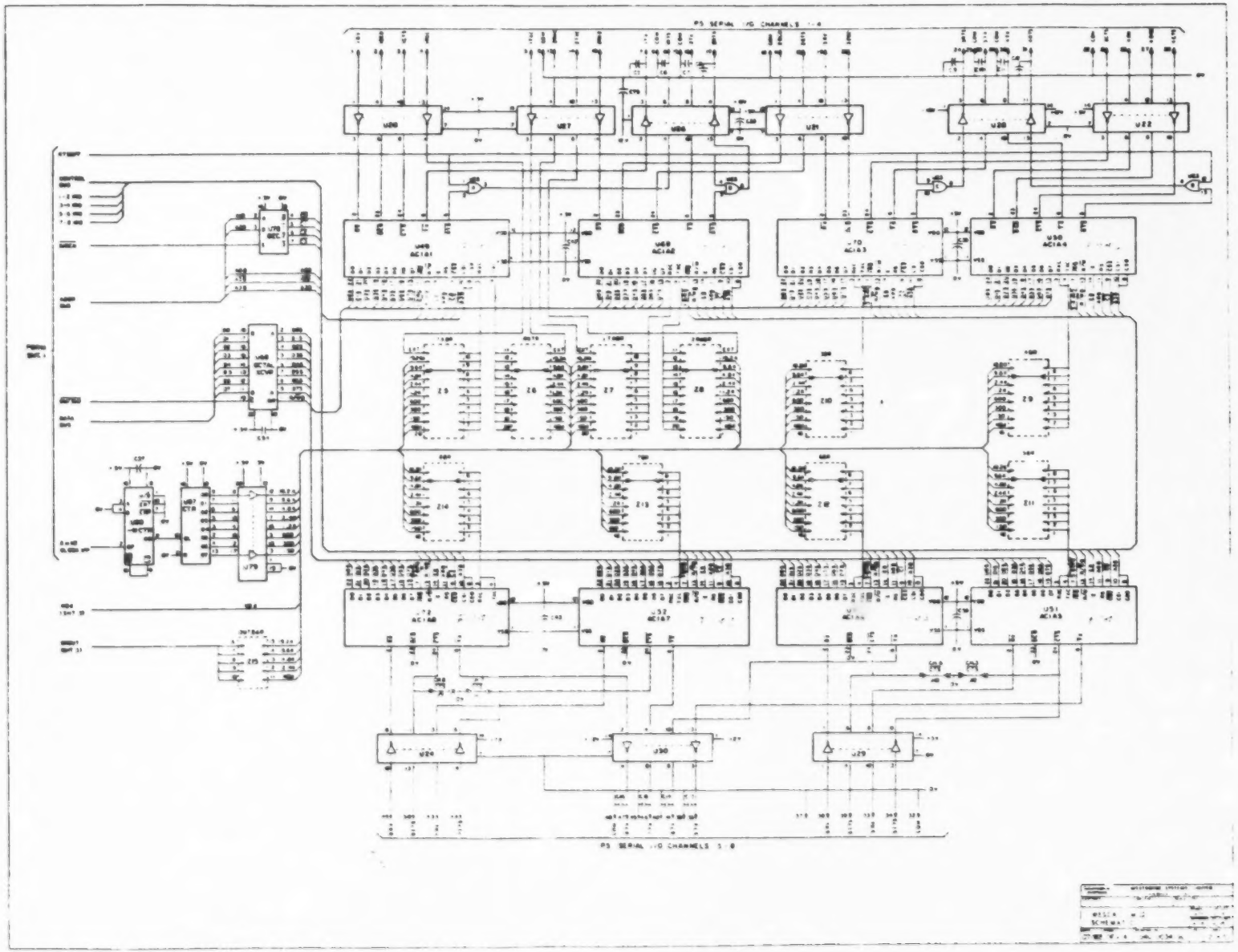
#	Control Outputs	
Ø	Water Addition Solenoid *	OPEN/CLSD
1	Magnetite Feeder	ON/OFF
2	Magnetite Dribble Feeder	ON/OFF
3	Dilute Level Cntrl Cone *	ON/OFF
4-15	Spare	ON/OFF

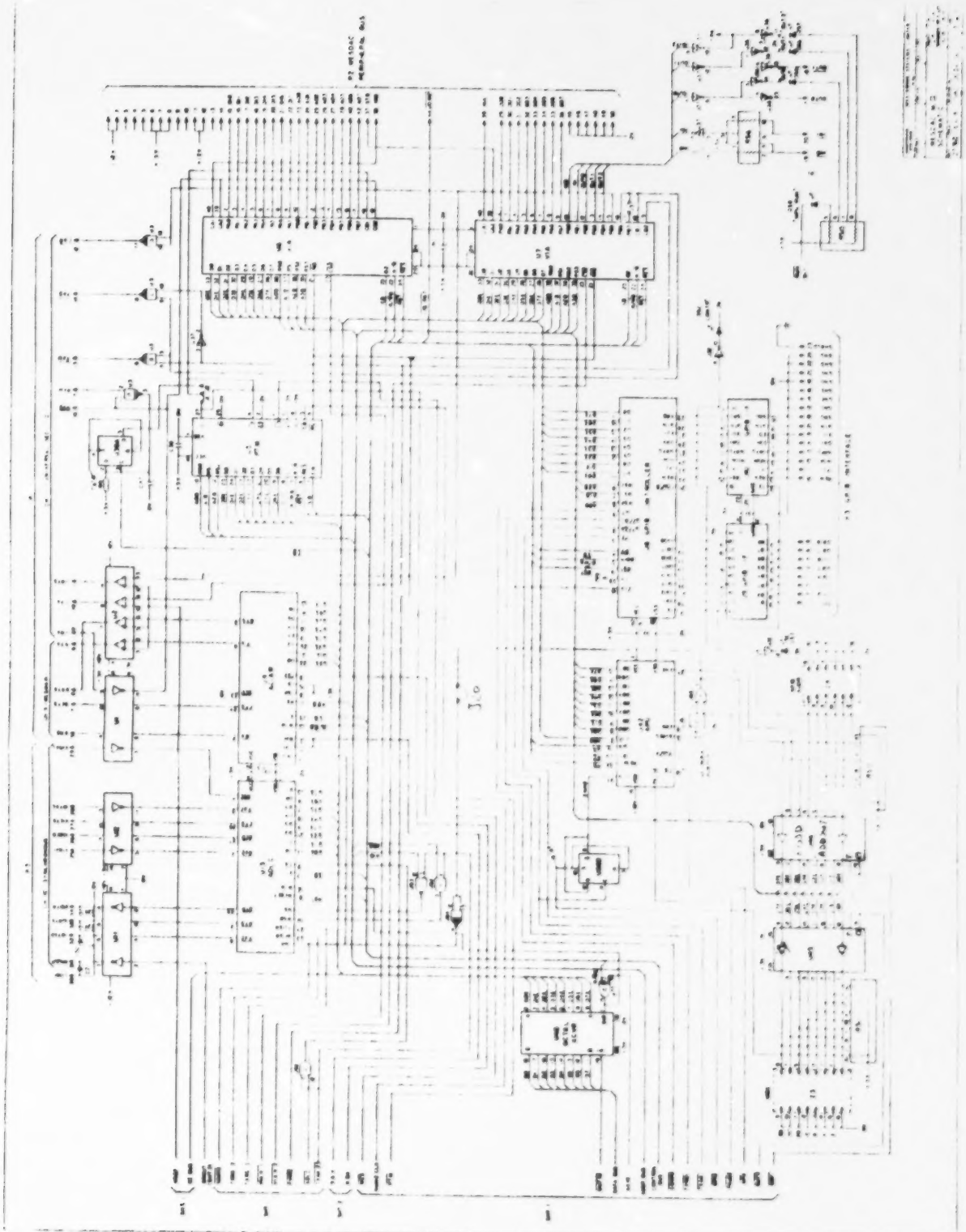
	Analog Outputs	
ØØ	Density Control Cone *	Ø-4Ø95

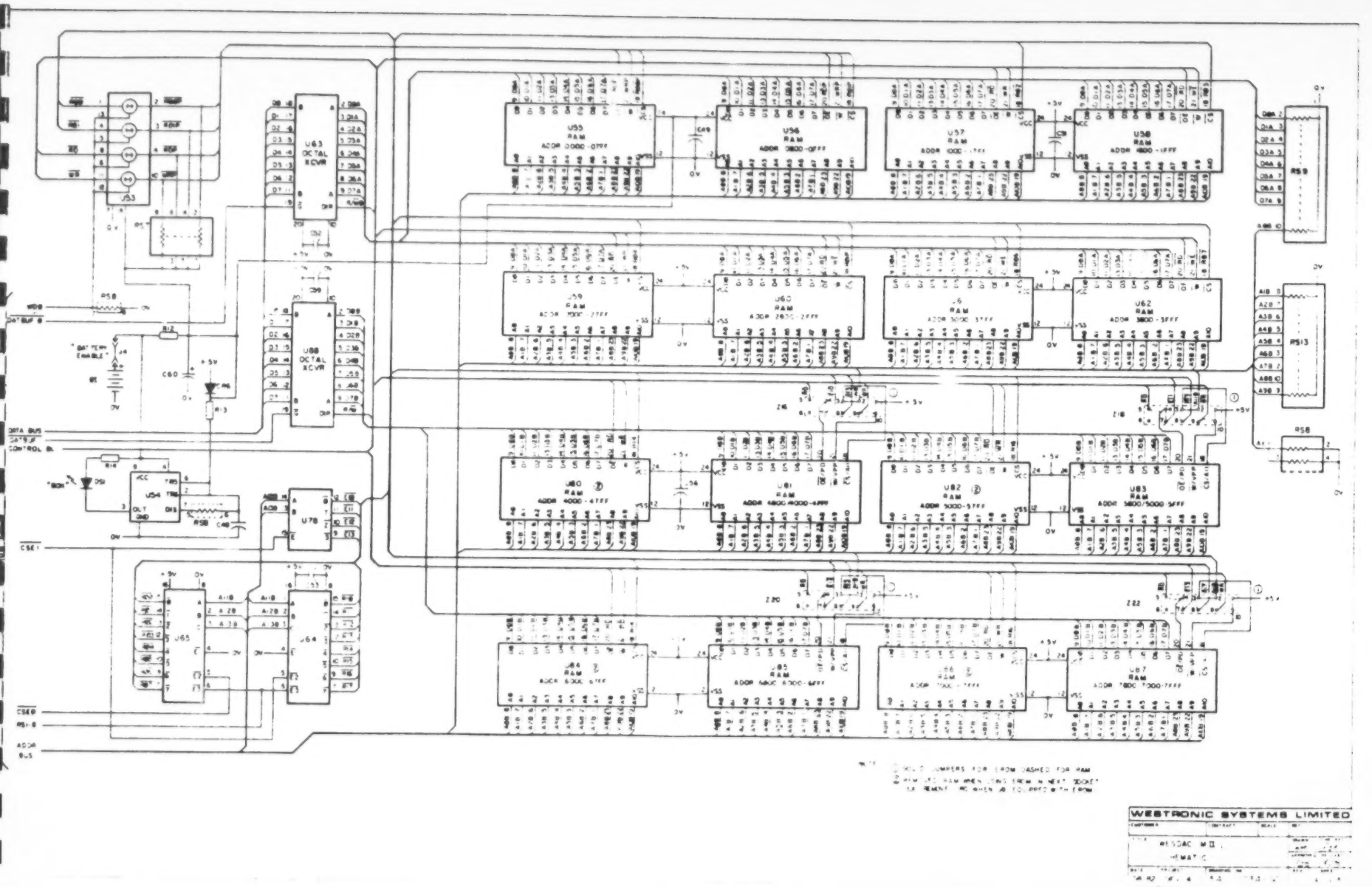
* Device can be automatically controlled.

DATAR SYSTEMS

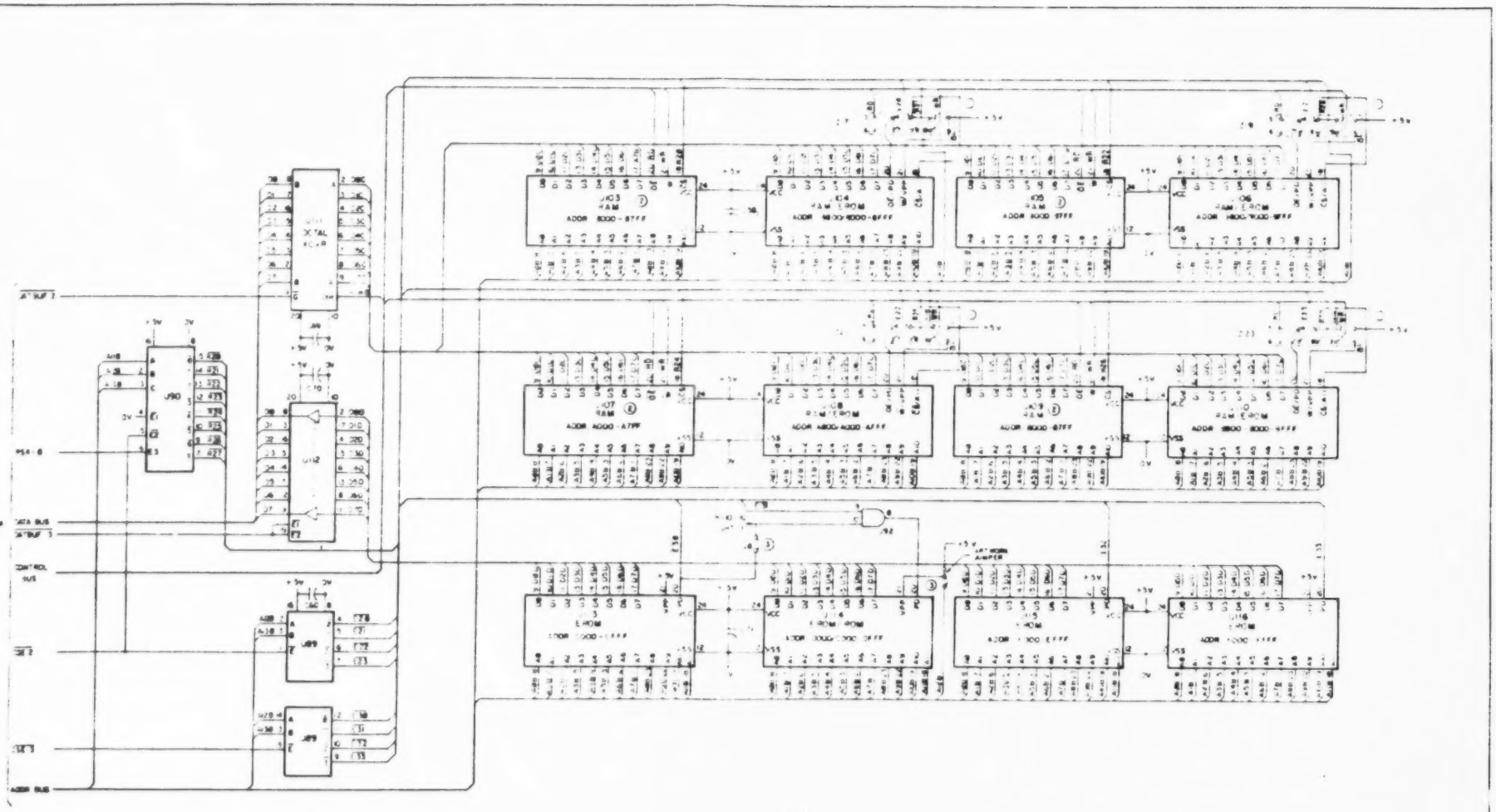




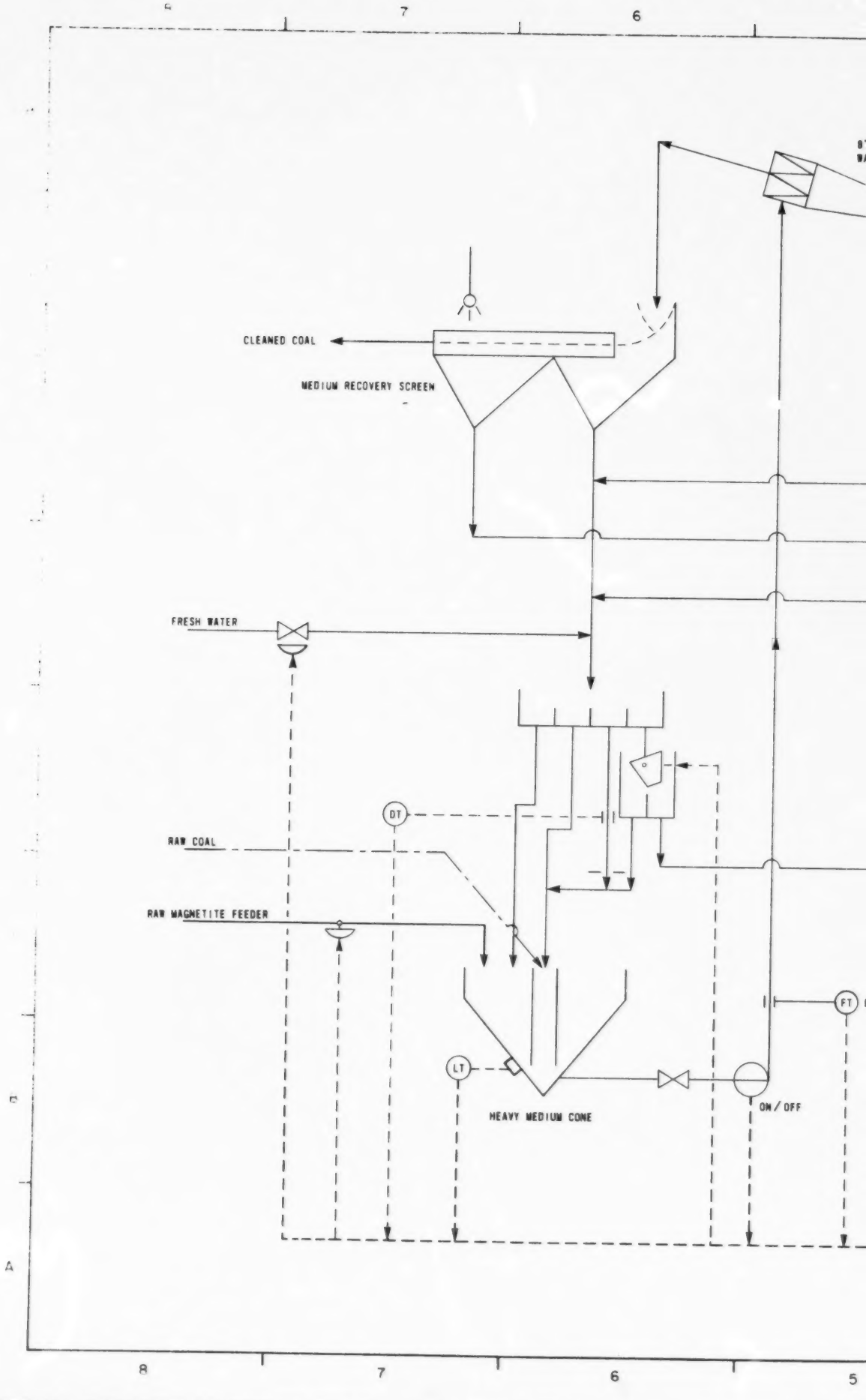




WESTRONIC SYSTEMS LIMITED



WESTRONIC SYSTEMS LIMITED


CLEANED COAL
MEDIUM RECOVERY SCREEN
FRESH WATER
DT
RAW COAL
RAW MAGNETITE FEEDER
LT
FT
HEAVY MEDIUM CONE
ON / OFF
8
7
6
5
A

NOTES

AM HEAVY MEDIUM
ING CYCLONE

DISCARD

MEDIUM RECOVERY SCREEN

MAGNETIC SEPARATOR

OPERATOR INTERFACE

COMPUTER SYSTEM

INPUT / OUTPUT SYSTEM

NOTE:
SEE 1338 - 003 - D FOR COMPUTER SYSTEM DETAILS

URE

LT

DILUTE MEDIUM CONE

ON / OFF

REVISIONS

7-2-85

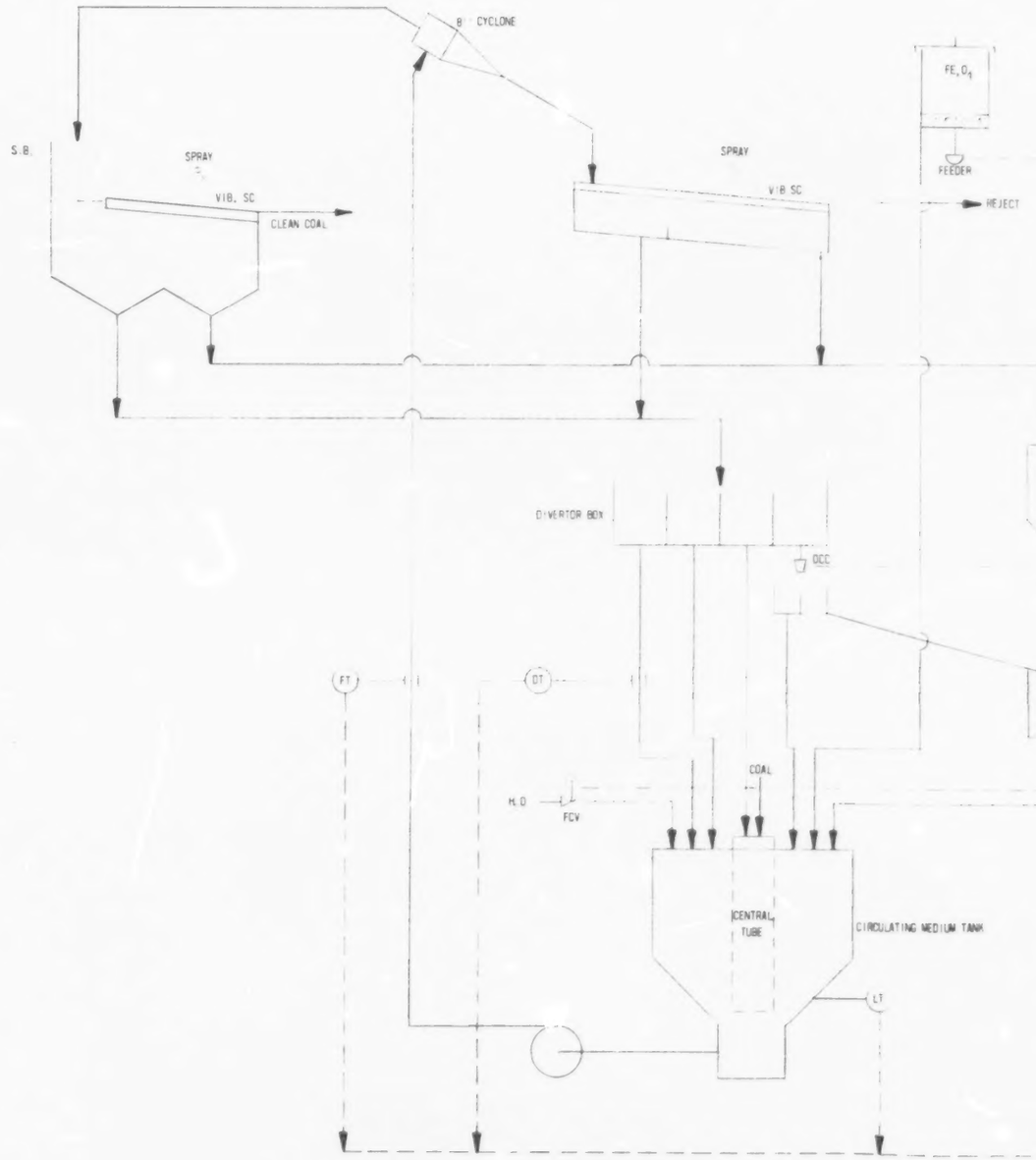
DATAP SYSTEMS A DIVISION OF

EMR - CARMET

HEAVY MEDIUM CYCLONE CIRCUIT

SCALE	PROJECT No	DRAWING No	REV
—	1338	1338-001 - D	0

NOTES



NOTE
SEE SHT 2 OF 2 FOR COMPUTER SYSTEM DETAILS

REV	DATE	DESCRIPTION	BY	CHKD

REVISIONS

DRAWN BY	DATE 17 / 4 / 92	CHECKED BY	DATE
ENG. APP.	DATE	MGR. MFG. ENG.	DATE

DATAP SYSTEMS A DIVISION OF
ALLEN-BRADLEY CANADA LIMITED
EDMONTON ALBERTA

WESTERN RESEARCH LAB

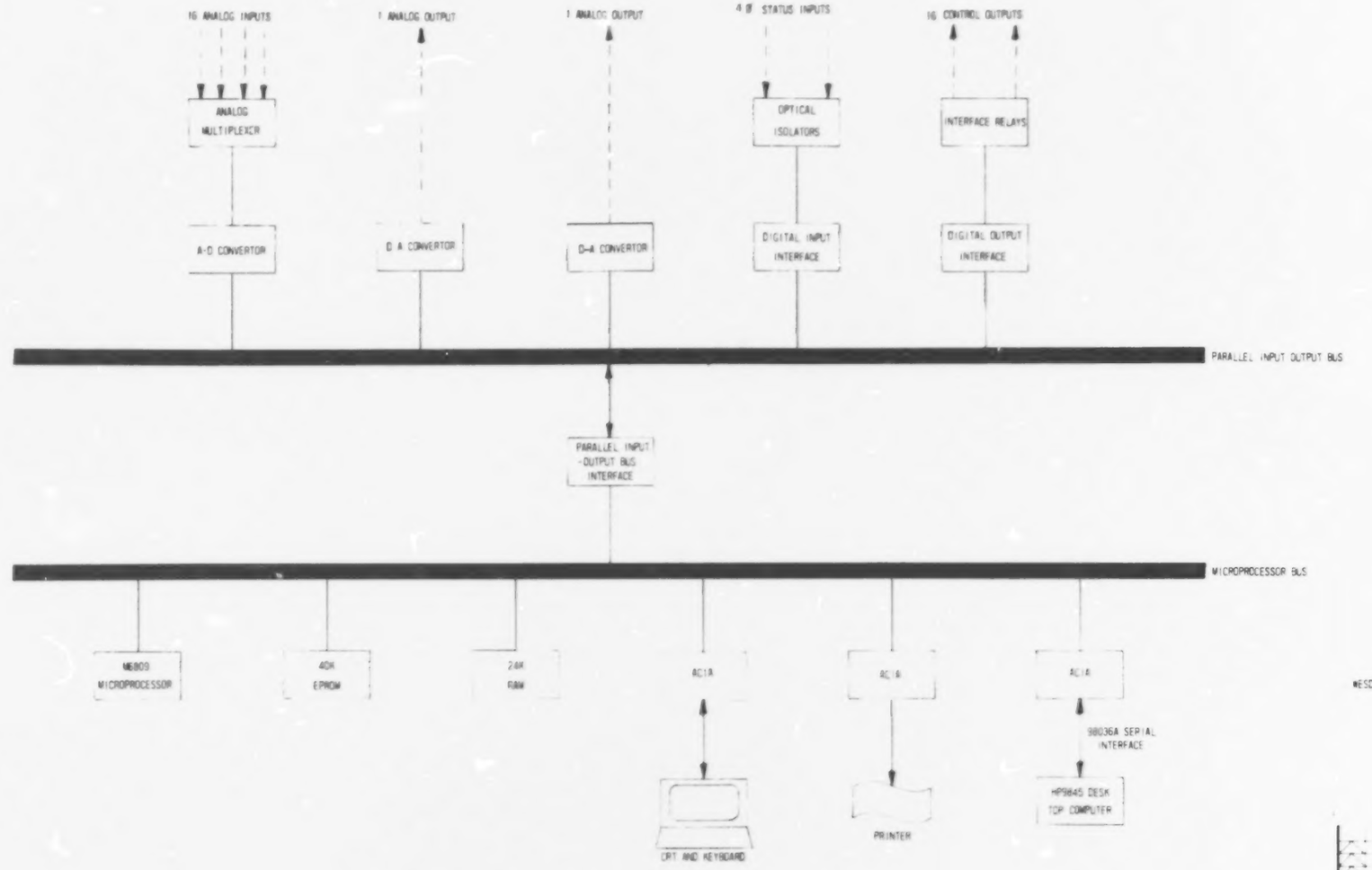
HMC DENSITY CONTROL SYSTEM

PIPING AND INSTRUMENTATION DIAGRAM

SCALE	PROJECT No	DRAWING No	REV
NTS	1336		

SHT 1 OF 2

NOTES



WESDAC M1 (SLAVE)

WESDAC M2 (MASTER)

REVISIONS

DATAP SYSTEMS A DIVISION OF

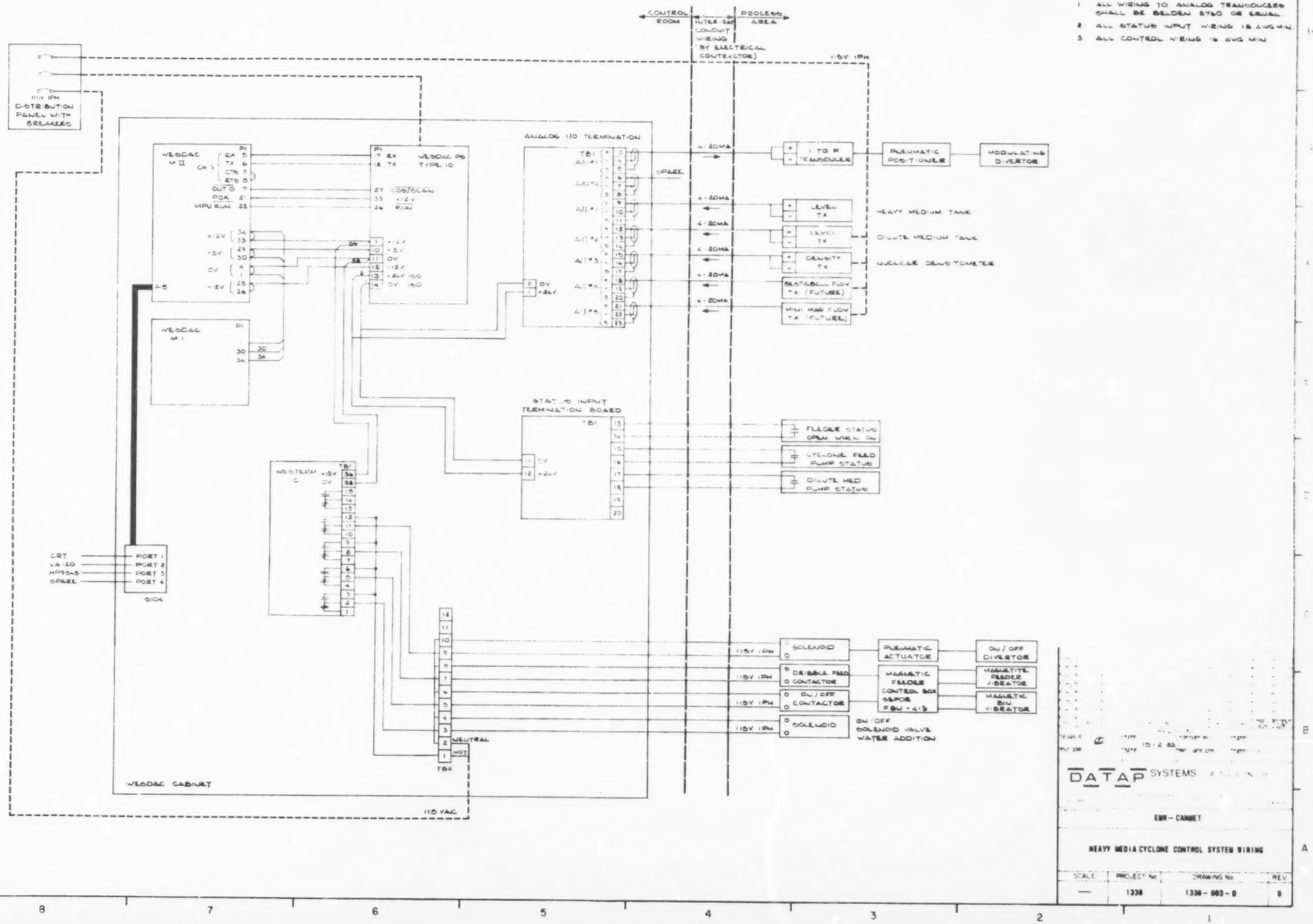
WESTERN RESEARCH LAB

HMC DENSITY CONTROL SYSTEM

SCALE	PROJECT No	DRAWING No	REV
NTS	1336		

NOTES

1. ALL WIRING TO ANALOG TRANSDUCERS SHALL BE BELDEN 8760 OR EQUAL.
2. ALL STATUS INPUT WIRING IS AWG MIN.
3. ALL CONTROL WIRING IS AWG MIN



DATAP SYSTEMS

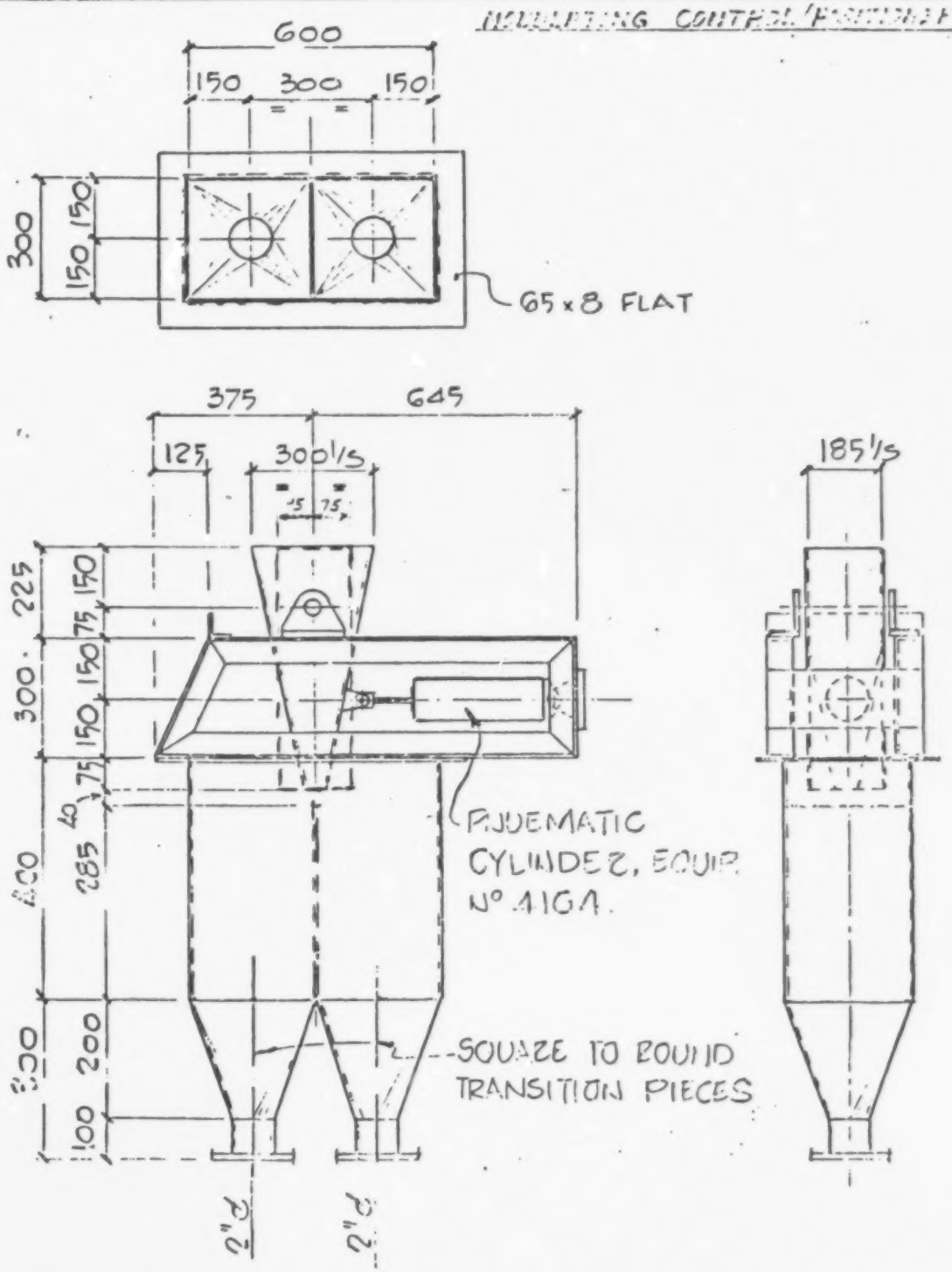
EMR – CANMET

HEAVY MEDIA CYCLONE CONTROL SYSTEM WIRING

SCALE	PROJECT No	DRAWING No	REV
—	1338	1338 – 003 – 0	0

SIMON-CARVES	JOB NO. C1835	EQUIPMENT NO. A-072
CLIENT: CANMET ~ COAL RESEARCH LABORATORIES	TITLE: 10 TPH COAL PREP PILOT PLANT.- SPLITTER BOX - HEAVY 02 DILUTE MEDIUM	

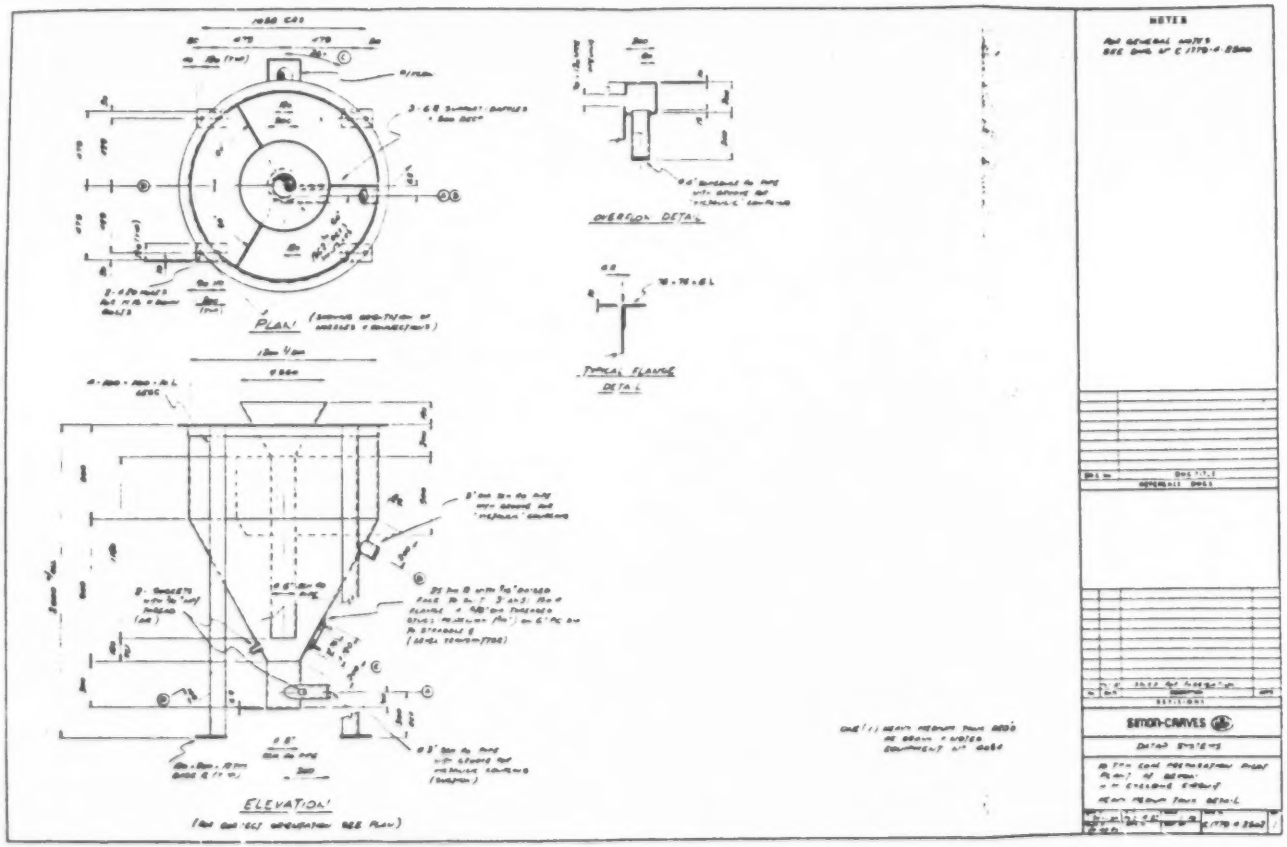
INCLUDING CONTROL POSITION TRANSDUCER



GIMA THK. PLT.

ALL PIPING 3" ø S.S. UNO.

DRAWN BY:	SKETCH NO.	REV.
DATE: 1'83	C1835.2/SK329	P


PLAN
ELEVATION
OVERFLOW DETAIL
TYPICAL FLANGE DETAIL
METER
SEITZ-CARVEL